ENVIRONMENTAL CONDITIONS AND CONSTRUCTION OPERATIONS in the NORTH SLOPE of ALASKA

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Environmental Conditions and Construction Operations in the North Slope of Alaska

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ABSTRACT

Extensive studies have been made on environmental conditions in the North Slope. The presentation (illustrated with slides) places particular emphasis on physical surroundings such as climate, land, and water. Also covered are plant and animal life, inhabitants, communications, transportation, and recent construction operations.

INTRODUCTION

When Atlantic Richfield and Humble discovered the rudhoe Bay field in 1968, many people heard of our comany for the very first time. This is not too surprising ce most people identify an oil company with the brand gasoline they buy. Our company markets Atlantic troleum products on the East Coast, Richfield on the West oast, and Sinclair elsewhere. We are now in the process changing over to one brand name for all of our products.

Atlantic Richfield is not the largest in the industry by y means, but its assets of something over 4 billion dollars, d its employees totaling something in excess of 25,000 peo make it a company to be reckoned with.

Obviously, Atlantic Richfield has not always been as ge as it is now. It all began in 1911 when the governnt took action to break up John D. Rockefeller's monopoly. e Atlantic Refining Company was split off from the old ndard Oil group. At that time, the company was a leader refining but did not produce any crude oil. It found itself the position of having to purchase oil from competitors, ree it, and then try to sell it at competitive prices. Through years, the company acquired crude reserves through covery and purchase of smaller companies having proven erves.

In the early 1960's, the Atlantic Refining Company pursed a small company in New Mexico called Hondo Oil npany, owned by a man by the name of Robert O. Ander In exchange for his company, Mr. Anderson was given zeable amount of Atlantic stock, and was made a member he board of directors of Atlantic. Mr. Anderson's leader soon brought him to the position of Chairman of the rd of the Atlantic Refining Company, and the company the breath of new life, new vigor, and new adventure. y exciting things began to happen, such as the discovery he Sasson Oil field in the Persian Gulf, the merger with Richfield Oil Corporation on the West Coast, discoveries he North Sea, Indonesia, Timor Sea, Cook Inlet and th Slope of Alaska and, most recently, our merger with lair Oil Corporation.

By now, everyone who knows anything about oil and its development knows that vast amounts of hydrocarbons were discovered when Prudhoe Bay State No. 1 was drilled on the North Slope. A confirmation well some seven miles to the southeast of the discovery well was drilled with substantially the same results. Subsequent evaluation of the find and the confirmation led to the announcement of the discovery of an oil field potentially the largest on this continent, and second only to the vast Middle East fields. Estimates of reserves run up to 10 billions of barrels; subsequent exploratory drilling and leasing suggests that 12 to 15 billion barrels of oil have been discovered by industry in the North Slope. If the 15 billion barrel figure were to be correct, it would equal about half of the present proved reserves of the United States.

These discoveries have been made at a time when the national and international concern for our environment began to develop to its present level. We all recognize that there are many logical and practical reasons for immediate and long range concern.

Our company recognized that many problems would arise in the development of the Prudhoe Bay field, so we took immediate steps to conduct an environmental survey of the North Slope to gather data to help solve problems as they arose. A great deal of information was obtained during our survey, including weather data, aerial photography, mapping, hydrographic surveys, soil borings, and soil temperatures. The results of our findings indicated that major problems existed, including the transport of crude oil from its warm abode deep inside the earth, upward through the permafrost, and thence through pipelines located in the arctic environment.

Other problems involve drilling, road construction, pipelines, water supply, sewage disposal, and a host of other operations that would be relatively simple if the oil field were located in a more temperate climate. For a better understanding of these problems, we will review briefly a few facts about the location and environmental conditions surrounding this new source of oil, and then look at recent construction operations that are taking place on the Slope.

LOCATION

This is Alaska

It occupies one sixth of the land area of the entire United States. It contains 375 million acres and is over twice as big as Texas. The Federal Government owns 97% of the land.

It has the smallest population, less than 300,000 people, or about 1 person per 2 square miles. Its largest city is Anchorage, with 50,000 people in the city limits and about 160,000 in the metropolitan area.

It has 6,042 miles of highways, less than Massachusetts, d 500 miles of railroad track. It is the flyingest state in e union, with 1 airplane per 100 Alaskans.

It has 6,640 miles of coastline, more than that of all the st of the United States.

Alaska was purchased from Russia in 1867 for 7.2 million llars, or about 2 cents per acre. It became the 49th State January 3, 1959.

rth Slope

The North Slope of Alaska lies between the Brooks Range the south, and the Beaufort Sea on the north. The Brooks nge extends east and west across the state, and separates e North Slope from the Yukon Valley which lies to the uth of the Range.

Naval Petroleum Reserve No. 4 is located to the west the Colville River.

The Arctic National Wildlife Range is located in the rtheastern corner of Alaska. The Canning River is its estern boundary. The Range extends southward to the ooks Mountain Range.

The state-owned land lies between the Colville River on e west, and the Canning River on the east. It extends uthward from the most northern point on the Beaufort a coastline about 5 townships, or 30 miles north and south, d narrows to just a few miles at the mouth of the Canning ver. This is the area in which the State of Alaska recently ld leases amounting to over 900 million dollars.

udhoe Bay Field

The Prudhoe Bay field is located in the southern vicinity the Bay, and near the Sagavanirktok River where it npties into the Beaufort Sea. The field is about 395 miles rth of Fairbanks and 200 miles ESE of Point Barrow, the ost northern point in Alaska.

ountain Passes

The Anaktuvuk Pass is the main passage through the ooks Range. The village of Anaktuvuk is located at the rth end of the Pass. The Anaktuvuk River flows north om the village into the Colville River. The John River ows south through the Pass to Bettles on the Koyukuk ver. The elevation of the Pass is about 2100 feet above a level. By comparison, some of the higher peaks of the ountains have an elevation of 8000 to 8800 feet above sea vel. The Dietrich Pass is about 70 miles east of Anaktuvuk, d provides a more direct route to the south from Prud-oe Bay.

CLIMATE

One of the obvious handicaps to operating an oil field the Arctic is the weather. It is necessary to winterize illing rigs with enclosures and heating systems. There e some clear sunny days in early or late winter, but most the time during the long winter nights, the drilling rigs esent a ghostly image through the dimly lighted foggy mosphere.

The recorded temperatures near Prudhoe Bay indicate low of —59°F in February, 1950, and a high of +75°F in ly, 1967. A maximum wind speed of 78 mph was rerded at Barter Island, about 112 miles east of Prudhoe Bay.

Temperatures fall below 0°F in every month except June rough September, and can fall below +32°F in every month roughout the year. Temperatures never get above +70°F except in July. The North Slope is not the coldest place in North America. An extreme low of —84°F has been recorded at Snag, Yukon Territory, Canada.

Precipitation on the North Slope amounts to about 4 to 6 inches per year, or about 30 to 50 inches of unmelted snow. When precipitation alone is considered, the area would be classified as semi-arid.

It is not part of the weather data, but it is well known that the North Slope is in the land of long days and nights. In the Prudhoe area, the sun never gets below the horizon between May 4 and July 30. Some of the favorite camera shots by visitors are of the midnight sun. In the wintertime, the sun never rises between November 24 and January 17. Pitch darkness, however, is rare. Maximum darkness occurs when the sky is overcast or when there is no twilight, moon, or northern lights. The stars by themselves transmit enough light through the clouds to prevent the type of pitch darkness which occurs in other regions.

The skies abound with sundogs, moondogs, mirages, and other bizarre sky phenomena rarely seen elsewhere. One of the better known spectacular displays in the Arctic North are the Northern Lights.

There are occasional thunderstorms, and sometimes they are followed by a rainbow.

Many people associate Alaska with earthquakes, but the North Slope of Alaska is located hundreds of miles from the so-called "Circle of Fire," which passes through the southern part of Alaska and down the western part of Canada and the United States. Extinct volcanoes can be seen on the inland plane route between Seattle and Anchorage.

LAND

Permafrost

The extreme low temperatures of the Slope have frozen the ground to great depths; therefore, the surface is underlain by thick continuous permafrost. Core samples were taken in the summer of 1968 to a depth of 400 feet with seismic drilling rigs. Subsequent coring with larger rigs, seismic data, and drill logging data indicate a permafrost depth of about 1800 feet plus or minus.

Temperature of permafrost just below the zone of seasonal variation generally ranges from about +12°F to +23°F. The temperature in the ground at a point about 60 feet below the surface is about +14°F. The thermal gradient from this point down to about 1800 feet amounts to approximately 1°F per 100 feet. The temperature of the oil in the reservoir is indicated to be about +160°F. When wells are drilled through the permafrost, great care must be taken to prevent thawing and sloughing of the sides of the drilled hole. Furthermore, when hot oil is produced upward through the well, it may cause thawing around the well casing and might result in ground subsidence of the thawed area. It is felt that the subsidence danger to the casing is slight, but at least two methods can be used for protection. One of these is "slip joints" in the surface casing, which are designed to permit differential movement between casing strings. The other uses insulation between the production string and the surface casing to restrict heat transfer to the permafrost zone.

Polygonal Areas

Other phenomena of the Slope are the extensive polygonal areas. When one views the ground from the air, there are areas that appear to be covered with a multitude of geometric figures. On closer examination, the figures appear

o be polygons, usually of four sides. These polygonal areas ormally occur in places where the top layers of soil have a igh silt content. This is true of most of the North Slope, ith the exception of river bottoms, which may be covered ith sand or gravel.

The silty sand overburden shrinks more in the wintertime an the underlying soils, mainly because the surface tem-eratures are much lower than those ten to twenty feet own. The shrinkage stresses will cause the upper part of e ground to crack open when its modulus of elasticity is ceeded, and this happens repeatedly every winter.

The cracks are always wider at the top than they are at e bottom because of the increasing temperature gradient wnward into the ground. During the summer months, the ater from the melted snow runs into the cracks and eezes. This seasonal cycle of cracking, filling with water, freezing and recracking, repeated over a period of many ars, has resulted in the growth of ice wedges in the ground.

A theoretical cross-section through a typical ice polygon licates an active layer at the surface of 3 to 8 feet deep derlain by permafrost. The spacing between ice wedges y be in the order of 25 to 100 feet. In general, the ice dges may extend 10 to 20 feet below the active zone. It thought that very few active ice wedges are more than to 40 feet in depth. The ice wedge may be several feet de at the top, depending on its age and whether it is ive or inactive. These figures are used for purposes of stration and are based only on judgment and best esti-tes. In addition to the ice wedges, the polygonal areas are o filled with random ice lenses. It is thought that the ice ses may have been formed when the upper layers of soil ze during the period when permafrost was first occurring the North Slope.

The growth of ice wedges in the ground is manifested on surface by rows of displaced top soil pushed upward and ward by the volume changes occurring in the polygons. h polygons are lower in the center and are called low ter polygons. In many areas, the low center polygons water filled throughout the summer. High center poly-s usually occur where drainage can take place during the w period, thereby causing the top of the ice wedge to ome successively lower each year. High center polygons also be caused if deposition or thawing is more preva- than the up-pushing of the soil, or if the material being hed up cannot maintain itself in a low ridge.

Many ice wedges can be seen along the caving banks of Sagavanirktok River where the soil has been washed y to expose the deep wedge forms.

f a pit is dug in the permafrost, the exposed ice wedges melt in warm weather and cause the sides of the pit ollapse. Ice wedges are most apt to begin melting at the rsection of polygonal lines.

Gravel airstrips and roads have to be built with sufficient h width to prevent damage from ice wedges melting eath the side slopes. It is not hard to imagine the dam-to structures built on polygonal areas. Careful attention t be given to the design of foundations, pipelines, flares, s, airstrips, etc.

oes

ingoes abound throughout the North Slope area. A o is a mound or small hill on the otherwise flat land-e. They are seldom over 25 feet in height in the Prudhoe area, but some of the larger ones in the Mackenzie Delta of Canada are reported to be up to 300 feet high.

There are two main types of pingoes. The open system type is caused by underground water flowing up and freezing near the surface. This type is usually found in areas where the relief provides a hydraulic gradient. The closed system type develops where a volume of saturated soil becomes completely confined by impervious material so that expelled pore water cannot escape. It usually forms in the sub-soils beneath drained lake beds or alluvial islands. This is the type of pingo usually found near Prudhoe Bay.

Tundra

While the pingoes and ice wedges are both unusual and interesting, the tundra is an oddity one would not expect to see in such a cold place. Tundra is defined as a rolling, treeless, usually marshy plain. The term is most often used on the North Slope when referring to the dense growth of vegetation which covers the ground.

In the wintertime, the tundra is frozen hard and covered with snow and ice. The entire Slope is uniformly white, and vehicles can travel anywhere across lakes, rivers, and marshes. This is no surprise, but it is a surprise to see the Slope in the summertime after having first seen it in winter.

The rising temperature of the Arctic summer melts the snow and ice, and the upper layers of the tundra begin to soften. Soon the warmth of the sun converts the surface of the frozen land into a multitude of lakes, interspersed here and there with rivers and patches of land. The land areas begin to turn green, and the 24 hours of daylight literally cause the flowers and grasses to spring out of the ground. The whole Slope appears to be a myriad of lakes sprinkled profusely over a green meadow. This resemblance to a green meadow is, however, deceptive because a closer examination shows that the thawed tundra has become a soft wet mass of grasses, flowers, stems, roots, and mud.

In a few of the higher, better drained areas, the thawed tundra becomes dry enough to afford safe passage on foot by humans and wild animals. In most areas, however, wheeled or even tracked vehicles will sink down through the soft tundra until they rest on the permafrost one to two feet below. Such a passage across the tundra would destroy its insulating capacity, and would cause the underlying permafrost to start melting. In a short while, the wheel tracks would appear to be two waterfilled ditches.

WATER

Lakes and Rivers

It is a paradox that, despite the semi-arid climate, there is also an abundance of lakes and marshes. This is due to the fact that most precipitation remains very close to the point where it falls. Runoff is prevented by the flatness of the land, and percolation is prevented by the underlying permafrost.

Most lakes are less than six feet deep and generally freeze all the way to the bottom. The few lakes over six feet in depth will in general be frozen to a depth of five or six feet with unfrozen water below. The ice on all of the lakes in the Prudhoe area melts and disappears in the summertime.

Nearly all lakes tend to assume a rectangular shape parallel to one another and are oriented approximately north and south. The actual bearing through the long axis of the lakes is about N12°W.

The Sagavanirktok is a typical tundra river of the North pe. It flows north across the Slope from the Brooks ge, and empties into the Beaufort Sea near the Prud- Bay field. The river is fed by the melting snow and ice he mountains and foothills. Some of the water from the ting snow finds its way into the river, but surface drain- is poor, and most of the water remains in the thawed dra or lakes until it evaporates. This river has been the nary source of gravel for road building and other con- ction in the Prudhoe Bay field.

ufort Sea

The Beaufort Sea extends from Point Barrow on the t to the Canadian Arctic Islands on the east. The periodic has an insignificant range of about six inches, as com- ed to tides of 20 to 30 feet that occur in the Cook Inlet on southern coast of Alaska.

There is an abandoned DEW line station located at Point ntyre on the coastline a few miles north of the Prud- field, but it is impossible in the wintertime to tell where land stops and where the water starts.

The coastal waters of the sea are frozen about ten months of the year. The shore-fast ice begins to melt in early e, and the edge of the ice packs retreats further from re. It is, therefore, possible to transport materials by ge up through the Bering Sea and from the Mackenzie er in Canada while the sea is ice free.

Several icebergs grounded offshore from Prudhoe Bay he early part of 1969. One of the icebergs grounded in eet of water about 25 miles out from the coastline. Sea er was pumped to the top of the iceberg and allowed to ze in an attempt to add weight and stability to the erg. Excess unfrozen brine water from the upper surface he iceberg froze as it ran over the outer perimeters, and ned icy curtains that hung down to the ice floes below.

PLANT AND ANIMAL LIFE

One cannot help but be impressed by the existence of n grasses and flowering plants on the Slope. Many its do not even flower. They reproduce by sending out ners on underground shoots. Nearly all plants are pe- nials, which insures a species survival when the short mer is interrupted by a killing frost.

Small animals such as parka squirrels burrow into the and dry places in the tundra, and manage to survive ugh the long harsh winter season. During this deathly od, all small animal life seems to disappear into the saving tundra layer. This layer of about one foot or so hickness is underlain by permafrost with temperatures n to —20°F, and overlayed by atmospheric temperatures ging down to as low as —60°F.

The caribou get around fairly easy on the soft tundra, prefer to follow established trails unless they are ntened by helicopters, airplanes, or other encroachments their tundra domain. Although large herds of caribou seen frequently in the summertime, they seem to scatter are seen less frequently in the wintertime. The sizes of s and their migratory habits are being studied by Com- ecologists. By early September, most of the herds disappeared from the Prudhoe area.

The Arctic fox is seen quite often at Prudhoe Bay. Its fur turns from brown or gray to pure white in winter.

everal species of birds exist in the North Slope environ- t, but the ptarmigan is a true tundra creature. It lives in the north the year around through good years and bad.

Polar bears wander on the Polar icepack in search of seals, and will occasionally come ashore on some remote Arctic coast.

INHABITANTS

Before the DEW line was built, and before discovery of oil at Prudhoe Bay, the Eskimos were the sole inhabitants of the area. But even before this, most Eskimos had abandoned the harsh life of the barren country in favor of the comforts of community living. Many Eskimo families have assumed permanent residence in Barrow, Barter Island, and Anaktuvuk. The only remaining signs of the early Eskimos in the Prudhoe area are a few collapsed sod houses and the remains of a camp area on the southeast side of Prudhoe Bay. Evidence of past life in the area is shown by the discovery of artifacts and bones.

There are a few trappers' huts on the Colville River, and an abandoned whaling station at Beechey Point. It is of interest to note that the whaling station building was erected on a sod insulating pad placed on top of the tundra. Some of the DEW line stations are still active, but some have been closed and abandoned. There is one European family reported to be living near the mouth of the Colville River.

Buildings in Barrow are both modern and primitive. Some dwellings are built of sod, have outdoor plumbing, and water supply is obtained from blocks of ice placed just outside the front door. According to one report, the water ice sells for 35 cents per cubic foot and unfrozen water for $3.00 for a 55 gallon drum.

COMMUNICATIONS

The DEW line station at Oliktok is operated by civilian technicians employed by contractors to the Federal Government. Among other things, the DEW line is also a system of communications—telephone, teletype, and radio transmission. The major outposts are connected to the combined North American Air Defense Command headquarters at Colorado Springs, Colorado.

The DEW line station at McIntyre has been decommissioned and the communications tower pulled down. All of the buildings are still in good repair, and kept open at all times for survival purposes.

Telephone service from Dallas to Prudhoe Bay is possible via ACS (Alaska Communications System).

TRANSPORTATION

Transportation to the Slope is mainly by air or water, as traffic over land is almost non-existent except in the wintertime.

Among the many types of planes used for transportation are the Boeing 737 for passengers, Lockheed Hercules for freight, and the Sikorsky Sky Crane for transporting specially designed drilling rigs. A Hovercraft is being used on a trial basis for transport of personnel and materials.

A few drilling rigs were transported to the Slope on barges in the summer of 1968. Some of the expeditions experienced difficulties on unloading the rigs on account of shallow water near the beach. An unloading operation took place at Beechey Point after an unsuccessful effort to land at Foggy Island.

ARCO and Humble constructed a docking facility and staging area on the southern shore of Prudhoe Bay to re-

eive barge shipments in the summer of 1969. Materials ere loaded on barges at Hay River in the Northwest Terri- ry of Canada, and shipped via the Mackenzie River and eaufort Sea to Prudhoe Bay. A similar shipment was made om Seattle, Washington, via the Bering Sea.

The highway and railroad system of Alaska is confined ainly to the Anchorage - Fairbanks area. Some state of- cials have indicated a desire to extend the railroad system to the North Slope. The State of Alaska built a winter ad in the early part of 1969 from Livengood to the North ope. The road terminated at the Sagwon airstrip in the gavanirktok River floodplain about 65 miles south of the udhoe Bay field.

Everyone is familiar with the voyage of the tanker Man- ttan to establish water transportation through the Arctic e. One can easily see the importance of this operation in tablishing tanker routes to the market areas by looking at world map and noting the central location of Prudhoe Bay.

The oil companies are also planning the construction of oil pipeline from Prudhoe Bay to Valdez on the southern ast of Alaska. Crude oil can be loaded aboard tankers at ldez, and be transported to West Coast refineries or else- here. Feasibility studies are being made for the con- uction of a gas pipeline from Prudhoe Bay via the western rt of Canada to the central portion of North America.

CONSTRUCTION OPERATIONS

ethods

Construction operations require that the permafrost be pt frozen and not allowed to degrade. This is accomplished maintaining the insulating tundra layer in an undisturbed ndition, and utilizing various methods to insulate and ele- te heat sources above the tundra surface.

Roads and airstrips are built by placing a thick layer of vel over the tundra. Gravel is a relatively poor insulator, the deficiency is partially offset by using a greater thick- s. Approximately 5 to 6 feet of gravel is necessary to vent the summer thaw from extending down into the mafrost.

Permanent buildings are supported on pile foundations elevated several feet above the ground level to allow circulation of air under the buildings.

Wood pilings are installed with butt end down in-holes ed in the permafrost. Pilings are plumbed in the holes, ich are then back-filled with a soil-water slurry mixture allowed to freeze. Freeze-back time required before ding the piling amounts to about two weeks in the latter t of the summer. At other times of the year, the freeze- k time would be shorter.

Water supply can be obtained from the unfrozen sand gravel deposits beneath the channel of the Sagavanirktok er. Provision is made to store water in a deep pond for emergency in case the river source fails temporarily. er treatment includes sedimentation and filtration. Pro- on is also made for the addition of chemicals.

Sewage treatment facilities consist of an extended aera- activated sludge plant whereby air is continually bubbled ugh the waste to provide oxygen needed for treatment he sewage. Plants are wholly enclosed in heated build- . The sewage effluent is discharged into holding ponds further checking and additional treatment if required.

All utility lines subject to freezing are protected by means nsulation, heat tracing, or by placing in heated utilidors.

Building complexes are connected by a heated passageway with water, sewer, and gas lines in a utiliduct below the floor and electrical cableways suspended from the ceiling.

The Prudhoe Bay State No. 1 discovery well and other exploratory wells were drilled from pile supported platforms. Development wells are being drilled with skid mounted drilling rigs supported on gravel fill drilling sites without pile supports.

The Prudhoe Base Camp consists of a complex of buildings for personnel and includes:

- Living Quarters
- Recreation Facilities
- Office Building

Service buildings include:

- Water Treatment Plant
- Sewage Treatment Plant
- Warehouse
- Generator Building
- Automotive and Welding Shop
- Vehicle Storage

All of the above buildings are connected by a heated passageway.

A crude oil topping plant has been constructed near the Sag River State No. 1 well to produce diesel fuel for local use. Processing of 5000 barrels of crude oil per day produces 1000 barrels of diesel and 4,000,000 cubic feet of gas. The gas is processed and then used at the base camp.

Airport facilities provide year-around access to the base camp. These facilities include:

- Gravel Airstrip 150′ wide by 5500′ long
- Hangar Building and Tie-Down Area
- Offloading Areas, Taxiways, and Sky Crane Pad

The living quarters can accommodate 215 men and contains a library, dispensary, laundry facilities, offices, and mess hall. The living quarters and office building were designed and constructed in Seattle, Washington, and transported to Prudhoe on barges, where the building sections were placed on pile supported foundations. The interior of the two story buildings contains a main lobby with mezzanine floor above and a mess hall that can handle 600 people.

The buildings are insulated, heated, ventilated, and lighted for year-around comfort even when the outside temperature drops to 50 or 60 degrees below 0°F.

CONCLUSION

Most problems associated with producing and transporting oil from the North Slope are due to the extreme low temperatures in the area.

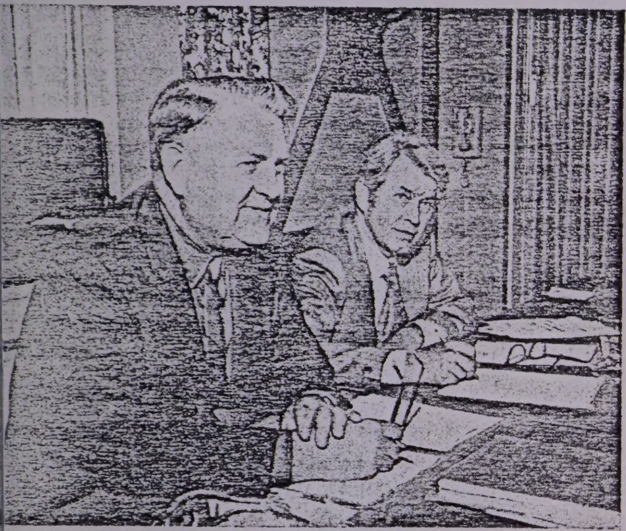
The Arctic area as we know it today has not always been cold. At some point in past history, the area must have been tropical. No one knows for certain why it turned from tropical to arctic. At any rate, there is a warming trend in the climate of the north that has been going on for at least half a century. The average temperature in Norway is reported to have risen two degrees since 1930. No one knows whether the warming trend will continue or not, but if it lasts another fifty years, much of the frozen north country would become more useful to mankind.

Unfortunately, we cannot wait on the evolution of earth processes to solve our problems for us. Furthermore, during the evolutionary processes, some of the problems would

ome easier to solve while others would be made more
icult. For instance, if the polar ice cap actually retreated,
nsportation through northern waters would become easier
, on the other hand, foundations and road construction
uld become more difficult on account of the deeper sea-
al thawing of the permafrost. In addition to this *small*
blem, some people are of the opinion that the melting
he polar ice would inundate a large part of the inhabited
a of the world.

In spite of small problems, and even when faced with
t looks like insurmountable problems, mankind has a habit of enduring, adapting, and working things out. Once an obstacle is recognized, analyzed, and evaluated, it can usually be overcome. Methods are evolved for our survival and advancement regardless of adverse environmental conditions, and our nature is such that problems must be solved and challenges have to be met.

The problems of making North Slope oil available for the welfare of mankind will be overcome. However, it becomes more apparent with each passing day that our objectives will take longer to achieve and will cost a great deal more money.



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